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Functional response of indigenous bacteria to a fungicide Quadris^R added to a loamy sand soil at increasing application rates

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Introduction:

Modern agriculture largely relies on the extensive application of pesticides as a part of pest control strategies. Fungicides are one of the most used pesticides, and although they are designed to manage fungal pathogens, their broad-spectrum mode of action also produces non-target impacts. Strobilurin fungicides, partially azoxystrobin are globally used to combat white mold, rot, early and late leaf spot, rusts and rice blast (Bartlett et al. 2001). Environmental concentrations of azoxystrobin higher than the regulatory acceptable concentration have been found in ecosystems, which pose a serious risk to soil organisms (Zubrod et al. 2019).

Aim of the study

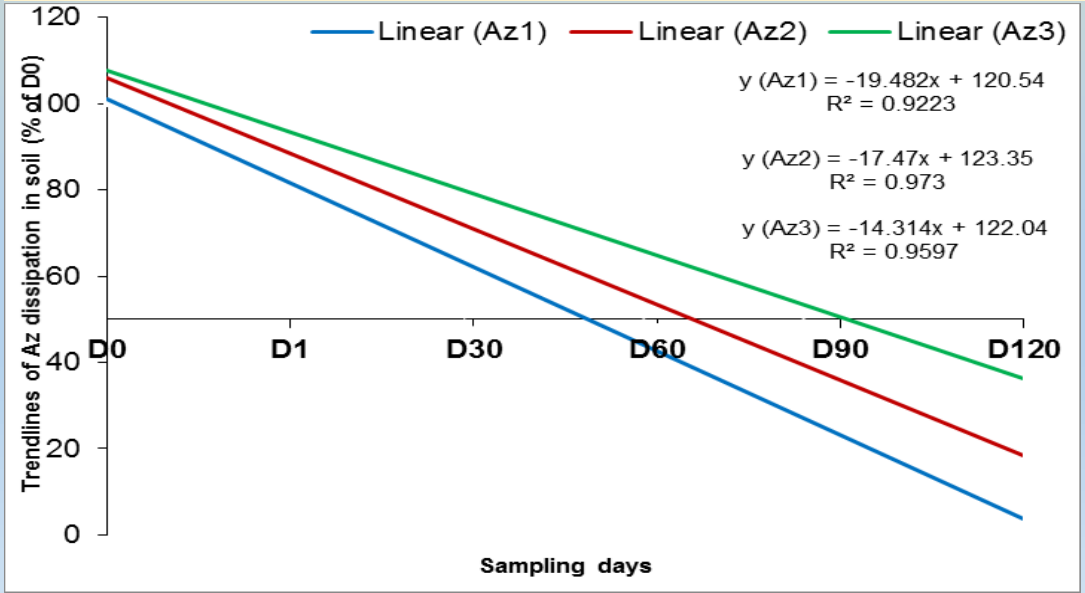
Non-target effects of fungicide Quadris^R (active ingredient – azoxystrobin) on bacterial metabolic activity were analyzed.

Material and methods

The study was performed with loamy sand soil (pH 5.6) and it was collected from grassland near Gabra village, Elin Pelin Municipality.

- ***Design of soil mesocosm:*** Soil mesocosms (2000 mg soil each) were constructed with increasing concentrations of fungicide Quadris^R calculated towards the active ingredient azoxystrobin methyl(E)-2-{2-[6-(2-cyanophenoxy)pyrimidin-4-yloxy]phenyl}-3-methoxyacrylate (Az) – Az1 (field dose (FD) - 2.90 mg/kg), Az2 (14.65 mg/kg) and Az3 (35.0 mg/kg), and unpolluted soil as a control (Az0).
- ***Soil Az residues:*** A gas chromatography (Hewlett-Packard – 5890 SERIES II) was used to assess the Az concentrations in soil, extracted by methanol : ethylacetate (75:25, v/v) mixture.
- ***Biolog EcoPlateTM assay:*** Bacterial capacity to catabolize different carbon sources was tested and it was expressed as total catabolic activity (AWCD) and community level physiological profiling (CLPP).
- ***Statistics:*** ANOVA was used to examine the differences in the means of Az and bacterial parameters; SIMPER analysis - to elucidate the difference between CLPPs and the main carbon sources that contributed to it. Statistics were performed using the package PAST (Hammer et al. 2001) at a level of significance $p<0.05$.

Results and discussion

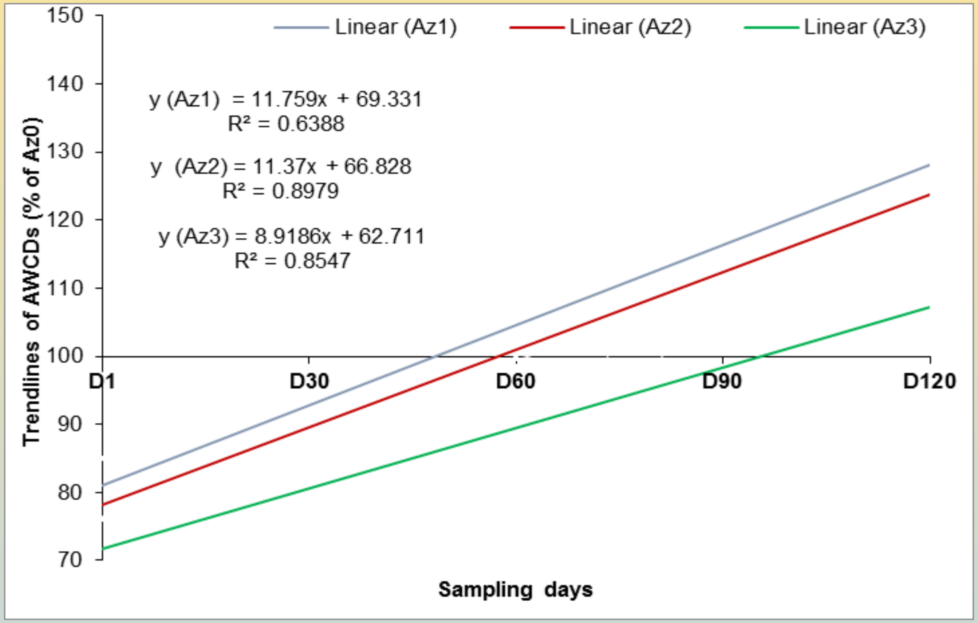


Az dissipation in soil mesocosms (% of D0)

- The Az dissipation well fitted a linear model of relationship between the incubation time of mesocosms and Az soil residues and the process of its dissipation was dose-dependent. .
- DT50 and DT90 values indicated that field recommended dose (Az1) of Quadris^R will affect directly or indirectly soil inhabitants for minimum of 37 – 122 days.
- The Az2 and Az3 expected effects on soil biota will be much more lasting - from two to ten months.

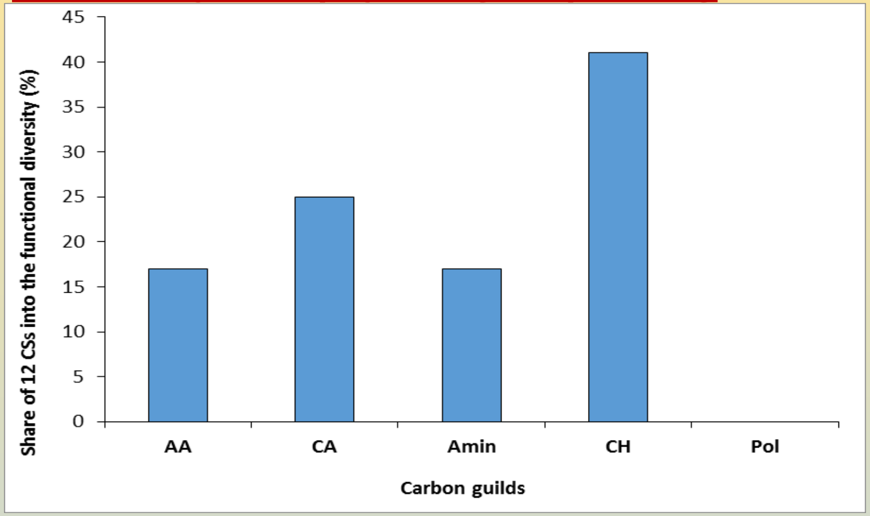
Results and discussion

Average well color development



- ❖ Catabolic activity of soil bacterial communities passed throughout three stages of development – inhibition, recovery and stimulation.
- ❖ The rate of bacterial catabolism was defined by the fungicide exposure time.
- ❖ Even FD caused changes in AWCD which lasted a minimum of four months.
- ❖ The difference between both Az1 and Az2, and Az3 increased over time, and it was more pronounced than that between Az1 and Az2.

Community level physiological profiling



- ❖ The overall dissimilarity among CLPPs was calculated to be 28.93% and only 12 of 30 Biolog carbon sources contributed to around 53% of the dissimilarity between CLPPs.
- ❖ Among the first most variable carbon sources were carbohydrates (41%), carboxylic acids (25%) and amino acids and amines (17% each), polymers were resistant to fungicide impact (0% variability).
- ❖ The great variability might be associated with the ability of bacteria to shift their metabolism to easily degradable substrates in order to gain more energy for stress overcoming.
- ❖ The metabolic shifts to carboxylic and amino acids (proteinogenic carboxylic acids) could be associated with their increased availability in situation of gradually decrease of soil pH and/or additional input of dead fungal hyphae.

Conclusions

- ❖ QuadrisR caused non-target effects on soil bacteria, influencing on their metabolism and capacity to utilize carbon sources of different chemical origin.
- ❖ The significant changes in bacterial functional profiles were related to the utilization rate of carbohydrates and carboxylic acids.
- ❖ The fungicide influence on carbon sources' utilization may destroy the complexity of nutrient cycling in soil and may influence negatively on soil health.

References:

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